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THE COLONIAL NEWSLETTER

P. O. Box 661 Hampden, Maine 04444 P. L. Mossman, M.D., Editor

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J. C. Spilman, Editor Emeritus

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EDITORIAL

This issue of *The Colonial Newsletter* completes my first full year as your editor - and indeed it has been busy, but time passes quickly when you are having fun. And fun it has been. Our subscriber list has continued to grow, now reaching 1,169. There is every indication that 1998 will continue to be as exciting. But remember, it is your valued participation that makes it work!

This is essentially a single paper issue with the presentation of a topic which has always fascinated me, contemporaneous counterfeit coppers, that is, coins which circulated in parallel with their legitimate counterparts. While many state coppers are technically counterfeits, having been struck privately without governmental sanction, the counterfeits examined by Charles Smith and myself in this present study are all cast copies of struck coins. In some instances, they are actually cast counterfeits of struck counterfeits! We have examined not only Confederation issues, but also cast imitations of Irish and English halfpence which were so prevalent in the small change medium of the 1780s. Although cast copper counterfeits are not common today, they are not particularly rare either if you are a veteran junk box scavenger. We believe, but can't guarantee, that the cast counterfeits we have selected for this study were contemporaneous with their real counterparts, rather than modern copies. Their condition is usually so poor, they never would have attracted serious attention from discriminating collectors of the genuine items. Until recently, they would have hardly fetched more than a few dollars in the marketplace, and, therefore, not a particularly lucrative object for 20th century fabrication. Using x-ray fluorescence spectroscopy, a non-destructive analysis of certain examples was conducted. Perhaps after reading this paper, patrons will want to reexamine their own lower grade material. Some lucky individuals may even find unrecognized cast counterfeits lurking in their cabinets, which, until now, had gone undetected.

This is a call for papers for the 14th Coinage of The Americas Conference (COAC) which is scheduled to take place at the American Numismatic Society headquarters on Saturday, November 7, 1998. This year's theme, "Circulating Counterfeits of the Americas," is a further study of contemporaneous counterfeits which circulated concurrently along side the legal issues they imitated. These coins are considered money of their times, albeit they were bogus, but excludes, by definition, any latter day forgeries produced to deceive collectors. Papers dealing with counterfeits from all North and South American countries are invited. If you have a presentation related to this subject, please discuss your ideas with, or send your abstract to, the symposium chairman, John M. Kleeberg, at the American Numismatic Society, Broadway at 155th Street, New York, NY 10032 (kleeberg@amnumsoc.org).

In the forthcoming August issue of *The Colonial Newsletter*, there will appear an extensive review of the Stepney Hoard of Connecticut coppers, featuring contributions and commentaries from several well known numismatists and researchers. In advance of its publication, your editor will present this paper at the Spring Meeting of the American Numismatic Society on April 18, 1998, under the title, "The Stepney Hoard of Connecticut Coppers - Forty-Eight years After the Fact (?)."

The Editor

Technical Note Numbering
CHANGE NOTICE

May we ask you to take a minute and make three changes in the Technical Notes (**TN**) numbering from previous issues? We erred in our numerical sequencing when duplicate numbers were inadvertently assigned. This can be easily remedied by the following:

Fugio Attribution Scheme (page 1699) should be renumbered **TN-179**.
Paul Revere: A Colonial Jack of all Trades (page 1751) now becomes **TN-180**.
What's New with the Bank of New York Fugio Hoard (page 1767) is now **TN-181.**

These changes appear in the current ***Cumulative Index for Issues 1-106.***
Thanks. **PLM**

IN MEMORIAM

RAYMOND H. WILLIAMSON (1907-1997)

It is with great sadness that we announce the death of Ray Williamson, a long time Patron and supporter of *The Colonial Newsletter*. From a personal perspective, he was always willing to assist in research projects and share the content of his extensive numismatic library. Ask Ray a question and expect a package of reprints within the week. I certainly agree with Mike Hodder's appraisal, "Ray was a gold mine and I don't think we ever found out how deep he went."

The following is a reprint of the notice prepared by James C. Spilman which appeared in the December 22, 1997, *CNL Online No.12*. **PLM**

Raymond Howard Williamson, a numismatist for 80 years, died December 13, 1997, at Virginia Baptist Hospital in his home town of Lynchburg, VA, where he lived since 1958. He is survived by Hazel Williamson, his wife of 67 years. Ray was born at Eagle Grove, IA in 1907, and received a BS from Iowa State, and an MS from Union College in Schenectady, NY; both degrees were in Electrical Engineering. He was employed by General Electric for 43 years prior to his retirement in 1972.

Ray first collected coins in 1917 when he was 10 years old. He was a member of the American Numismatic Society since 1949 and was a Fellow in the Society since 1957. He was also a member of many other organizations including the American Numismatic Association, Virginia Numismatic Association, and Early American Coppers Club. Ray was a Patron of The Colonial Newsletter Foundation.

His primary collecting interest was US large cents, however, his love of books and research led him to build an excellent numismatic library which provided the basis for assisting many other numismatists in research for their publications. He authored numerous papers which were published in *The Numismatist*, *The Colonial Newsletter*, *Coin World*, *Seaby's Coin & Medal Bulletin*, *Penny-Wise,* and *The Virginia Numismatist*, as well as numerous publications of The American Numismatic Society. He was an avid student of Lynchburg history and received the Numismatic Literary Guild Award for Extraordinary Merit for his article "Lynchburg City Paper Money of 1862," published in *Lynch's Ferry*, the official publication of the Lynchburg Historical Society. He also served as a member of President L.B. Johnson's Assay Commission at the Philadelphia Mint in 1968.

Employed by the General Electric Company from 1928 to 1971, he first served as Manager of Engineering Administration for communication products in Syracuse, NY, and later in Lynchburg VA, from 1954 to 1971. An electronics specialist, he implemented the "know-how" contract in Milan, Italy, in 1950, and managed the installation of a very-high-power naval radio telegraph transmitter in the Panama Canal Zone in 1936 and 1939. He was Chairman of the FM Broadcast Engineering Committee to formulate and promulgate industry standards from 1942 to 1953. During his professional career, he was published in *I.R.E. Proceedings* and *Signal* magazine. He was a fellow of the Institute of Electrical and Electronic Engineers, a member of the Elfun Society, Secretary of the Electoral Board of Lynchburg 1971-1980, and a member of State and National Numismatic Society. He was a Boy Scout leader in Schenectady from 1929 to 1944. He was a member of the Lions Club and The Civil War Round Table. As a member of the First Presbyterian

Church in Lynchburg, he served as a church elder and was a member of the Martin Gifford Sunday School Class since 1960.

He was preceded in death by his sister, Irene W. Evers. In addition to his wife, he is survived by two nieces, Virginia Pradt and Dorothy McCandless, both of Wisconsin.

A memorial service was held at 10:30 a.m. on Tuesday, December 16, 1997, at the First Presbyterian Church of Lynchburg with the Rev. Dr. James J.H. Price officiating. Diuguid Rivermont Chapel was in charge of arrangements.

Those wishing to make memorial contributions, please consider The First Presbyterian Church (Lynchburg, VA) Memorial Fund.

Cast Counterfeit Coppers in Pre-Federal America

by
Charles W. Smith, Ph.D.; Orono, ME
and
Philip L. Mossman, M.D.; Hampden, ME

Introduction

Ever since governments started to mint money, there have been those enterprising individuals who were ready, willing, and able to turn a quick profit by counterfeiting "the coin of the realm." This is one instance where it does not hold that "imitation is the sincerest flattery"[1] since in reality the counterfeiter is a thief who preys on the whole of society. There are two basic categories of counterfeit coins, the first being those clandestinely minted during the same period as the coins they imitate and specifically designed to pass as contemporaneous currency in parallel with the authorized issues. Since these counterfeit coins passed as real money, they can be as numismatically and historically interesting and important as their lawful counterparts. The imitation English halfpence from Machin's Mills and the New Jersey copper, Maris 54-k, attributed to a Mr. Hatfield, are examples of this type of counterfeiting. To be technically correct, only those Machin pieces with the same dates as the legal issues are true counterfeits whereas those dated otherwise are termed imitations of the legitimate coinages. The second category are those deliberate forgeries of valuable numismatic items made to be sold at a premium to unsuspecting individuals or institutions as intentional fraud. Many numismatic publications contain descriptions or warnings about such counterfeits infiltrating the legitimate marketplace. (These forgeries are not the same as legally sanctioned, appropriately marked, copies of rare coins for which there is no intent to deceive, but rather to provide a service to individual collectors and museums who wish to have a replica of an otherwise unobtainable, genuine specimen.) This paper deals with only the first category, contemporary circulating counterfeit coins, and specifically those coppers which were current in pre-Federal America.

To appreciate the problem of counterfeit coppers, it is useful to review briefly the history of English copper coinage. Until 1279, the only denomination minted was the silver penny, and, after that date, silver farthings, halfpence, and groats were also produced. As inflation ensued, these small silver coins became yet even smaller and debased in silver content by alloying with copper. The diminutive farthing was relatively expensive to mint since four farthings required four times the labor as the larger silver penny.[2] Since there were inadequate numbers of low denomination coinage for commerce, merchants came to their own rescue by circulating private tokens which appeared in a variety of base materials. These "pledges" were then redeemed by the issuing tradesman. The government turned a deaf ear to the needs of the common people until 1613, when James I outlawed merchants' tokens and introduced the copper farthing, minted initially under the Harington patent which was later assumed by Richmond, Lennox and Maltravers. These lightweight pieces, very unpopular due to their very low intrinsic value and diminutive size, reaped immense profits for both the patent holders and the monarchy, a factor which encouraged the appearance of many struck counterfeits. The Puritan government, which had come to power in the meantime, denounced base coinages and monopolies and stopped their production in 1644.[3] Again, the appearance of merchants' tokens filled the small change vacuum.

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[1] C.C. Colton (1780-1832): *The Lacon.*

[2] C.W Peck, *English Copper, Tin and Bronze Coins in the British Museum 1558-1958* (London, 1970), p. 2.

[3] John Craig, *The Mint* (Cambridge, 1953) p. 142.

Finally in 1672 the government met its obligation to mint small denomination coppers to serve the need of the common people. Since these were only a token coinage, the cost of production was added to their intrinsic value, but above and beyond the price of both materials and labor, there was an additional 25% profit margin for the monarchy. From 1685 to 1692, when less costly tin was substituted for copper, the royal gain was increased by a factor of three. This substantial profit margin was a great stimulant to any would-be counterfeiter who probably rationalized his activity with the lament, *If the king can do it, why can't I* ?

These regal coppers were struck on planchets cut from rolled copper sheets, except during the reign of William III, when private contractors, to reduce expenses, used cast planchets. Although previously noted that the patent farthings counterfeits were struck, all counterfeit copper and tin coinages before the reign of George II, that we have examined, have been cast. This is the same experience published by Batty.[4] Furthermore, of the five coppers of William and Mary in the Dunchurch copper hoard, four were genuine and only one a cast counterfeit, whereas of the William III coppers, fully a half was cast counterfeit.[5] Although large numbers of genuine coppers of this king were minted, many of these, as well as the earlier coppers of George I,[6] were melted down after 1725 and recast into three-quarter-weight counterfeits.[7] A very significant hoard of these William III cast counterfeits imported into Philadelphia was detailed by Newman and Gaspar.[8] Returning to the Dunchurch find, there were two struck and five cast forgeries of George I halfpence. For George II, there were seven cast and nine struck bogus young head halfpence and four cast and ten struck of the old head varieties. Of the entire find deposited about 1751, 63% of the hoard was counterfeit with progressively more struck imitations as the reign of George II continued. The "modernization" of counterfeiting technology is further documented in a letter published in 1752 in *Gentleman's Magazine*[9] which related that about seven years previously (1745), after a brief crackdown by officials on some Birmingham counterfeiting rings, the "makers" resumed again *last spring; these authors* [i.e. the forgers] *published their works in a new edition: the practice of making counterfeit halfpence was revived with this improvement, that whereas they were before cast in sand, they are now made in a stamp or press.* By the reign of George III, cast counterfeits are unusual whereas there are scores of different counterfeit die varieties, Batty alone listing 515![10] This transition from cast counterfeits to struck counterfeits is a reflection of the evolving industrial revolution where the heavy machinery for rolling copper sheet and stamping

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[4] In the Batty collection of 35,000 coppers, the only counterfeits listed for William III and George I were cast, whereas for George II, forgeries were both cast and struck from dies, several with "rude workmanship." D.H. Batty, *Batty's Descriptive Catalogue of the Copper Coinage of Great Britain, Ireland, British Isles, and Colonies, Local & Private Tokens, Jettons &c.* (Manchester, 1886) Vol. III.

[5] P.H. Robinson, The Dunchurch and Stafford Finds of Eighteenth-Century Halfpence and Counterfeits, *British Numismatic Journal*, Vol. 41 (1972) pp. 147-58.

[6] Robinson, p. 157.

[7] John Criag, *The Mint* (Cambridge, 1953), p. 253. By the early 1730s, forgers changed from this practice of melting legal coins for metal and started to use cheap commercial copper. In regard to the prevailing price of copper at that time, in 1718, the price of Swedish and Norwegian copper on the Amsterdam market rose abruptly by about 33% over 1710 levels, but by 1722, the price had returned to about 8% over baseline, indicating that copper was neither expensive nor in short supply in 1725. It has seemed curious that counterfeiters would ever have melted legal coins as their source of copper since, in any case, finished coins would be more expensive than sheet copper which was not relatively expensive in 1725. (N. W. Posthumus, *Inquiry Into The History of Prices In Holland* (Leiden, 1946) pp 372-77.)

[8] Eric P. Newman and Peter P. Gaspar, "The Philadelphia Highway Find," *The Numismatist*, 1978, pp. 453-67; Peter P. Gaspar and Eric P. Newman, "An Eighteenth Hoard from Philadelphia," *Coin Hoards 4* (1978), pp. 127-30.

[9] Vol. XXII, Nov. 1752, p. 500, as quoted in Mendel L. Peterson, "Eighteenth Century Imitations of British Regal Copper Coins," *The Numismatist*, Apr. 1956, p. 389.

[10] See Eric P. Newman, "English and Bungtown Halfpence" in Eric P. Newman, editor, and Richard G. Doty, associate editor, *Studies on Money in Early America* (New York, 1976), p. 169.

planchets even became available to the small entrepreneur. Coupled with the increased use of die making skills, it is not surprising that counterfeiting activities were concentrated in large manufacturing centers such as Birmingham and London. Thus we witness the progression from the cottage industry of casting to the industrialized process of striking counterfeits which we can now document as a well developed technology by 1752. Certainly by 1770, with the first regal issues of George III coppers, the counterfeiters had perfected their skills. Although one cannot prove when a counterfeit coin was made by its date, we assume that between 1752 and 1770, these minters were not idle and were probably busy stamping out retrodated George II coppers since the last legal issue for that reign was in 1754. Not only was this new industry profit driven, there was little consequence if the perpetrators were caught since the offense was treated as a misdemeanor prior to 1742, and after that, a conviction incurred a two year prison sentence with an additional “probation” requirement, after release, of two years of good behavior.[11] By 1771 counterfeiting had become such a rampant social evil that the law was toughened again, this time to make it a felony even to attempt to negotiate a false copper.[12]

Because of the significant profits that could be realized at minimal risk, counterfeiting of English coppers had emerged into a large-scale operation. In England, it was observed in 1751 that *every town and village had its mint*[13] and by 1753, it was estimated that half the circulating copper money was counterfeit,[14] a number supported by the Dunchurch hoard cited above. During our colonial period, some £69,000 of regal coppers were legally exported to British North America, but this sum was eclipsed in comparison to the countless tons of false coppers which arrived each year, an influx which was only temporarily suspended during the Revolution. In 1753, 31% of a shipment of halfpence arriving from England, inspected in New York, was found to be cast counterfeits of various dates.[15] It was asserted in 1789 that 95% of circulating coppers in New York were counterfeit, although this figure was challenged as an exaggeration.[16]

Since counterfeiting is not restricted by any national boundaries, it was only a matter of time before the activity transplanted to British North America. To roll copper sheet, cut planchets, and strike coins required a significant infrastructure that very few individuals could afford, but casting could be done where ever one had the facilities to prepare molds and melt metals, as, for example, in the fabrication of horse harness hardware or musket shot. While there was no significant mechanical minting of copper here until the Confederation period, we cannot be so certain about clandestine casting operations, which, due to the less complex technical requirements, would be much more difficult to trace. In the numismatic literature, frequent reference is made to the Swansea, Massachusetts mint which was responsible for some of the primitive copies of English coppers from dies, as substantiated by contemporaneous news reports.[17] Not only was Swansea a location where bogus coppers were struck, but also it was a documented site for cast counterfeits as detailed in a description of the Swansea “mint” by Lyman Low. Low, quoting early correspondence, describes how the Barney family of that town *are said to have cast, in sand-molds, facsimilies of the English Halfpennies of that period and circulated them as Cents*.[18] While the Swansea mint (or mints) was responsible for both struck and cast counterfeits, we do not know if these activities were sequential or simultaneous.

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[11] Peck, *op cit*, p. 205.

[12] 11, George III, Cap. 40.

[13] Craig, *op cit*, p. 253

[14] Rogers Ruding, *Annals of the Coinage of Great Britain and its Dependencies* (London, 1840), vol. 2, p. 102.

[15] Kenneth Scott, *Counterfeiting in Colonial New York,* ANSNNM 127 (New York, 1953), p. 102.

[16] *Federal Gazette*, Aug. 1, and Aug. 8, 1789 .

[17] This subject is reviewed by Newman, “English and Bungtown Halfpence,” *op cit*, pp. 154-56, 164-65, 170-72, who proposed this mint as the source of the 1784 counterfeit English halfpence, Vlack 14-84A.

[18] Lyman H. Low, *Hard Times Tokens* (1899), p. 40.

Researchers have often asked, *If it was apparent to everyone that these coppers were counterfeit, why did they continue to circulate in parallel with legal coppers*? Perhaps in part, the answer is simply that people needed small change and since most of the population were illiterate, any deviant inscriptions or designs were inconsequential to them, as long as they received just value for their money "without discrimination." Additionally, the officially lenient policy about the counterfeiting of coppers showed that the government wasn't particularly overzealous to eradicate the practice, and after all, the king, himself, was making a pretty good profit. Rhodes has suggested that when a government has a nonchalant attitude about the state of its money, copper in this instance, the people are not likely to concern themselves seriously about the counterfeit currency.[19]

So to this point we see a situation where high profit, and relatively low risk environment encouraged copper counterfeiting. This paper will focus on the cast counterfeits of English, Irish and State coppers, all of which widely circulated in British North America and later the American Confederation. The struck counterfeits of George III have already been extensively reviewed by Smith.[20]

Casting Technology

Since the activity of casting counterfeit coppers was illegal, it is very unlikely that any perpetrators actually recorded their techniques. Thus we must extrapolate from what is known about legitimate metal casting operations in the 18th century and from careful examination of the cast coins themselves. Casting is a very ancient technology extending back to the Bronze Age beginning in about 3000 BC. Seventh century Greek coinage was cast in electrum, whose weight was confirmed by an official stamp from a punch. In China, for centuries, bronze cash were cast in the shape of "trees" from which the individual coins were broken. In early Rome, ponderous copper coins, the *aes grave* (heavy bronze) were cast, but since anyone could use a legitimate coin as a pattern for a cast copy, precious gold and silver specie coins were always struck with dies, as a deterrent to counterfeiting.[21]

Besides coinage, legitimate or otherwise, casting techniques have a wide application to fashion anything from fine jewelry, to large industrial machinery, and even dental restorations. Whereas, nowadays, the counterfeiter has a whole assortment of sophisticated casting [investment] materials available with which to make an impression of the coin to be duplicated, in the 18th century the usual investment medium was very fine sand.

A. The Sand Mold

Several properties of the investment medium are essential to make a good mold, the primary one being that the mold material must withstand heat - or be refractory - since the temperature of molten copper is 1083ºC. Secondly, the mold must be sufficiently permeable to allow the escape of gases generated during the casting process, and lastly, the finished mold must be cohesive enough to maintain its shape and strength under the thermal stress of rapid heating. For centuries, these requirements have been met by naturally occurring green casting sand containing specific

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[19] Henry T. F. Rhodes, *The Craft of Forgery* (London, 1934) pp. 11, 192.

[20] Charles W. Smith, "The English George III Contemporary Counterfeit Halfpenny Series: A Statistical Study of Production and Distribution," *Coinage of the American Confederation Period,* COAC Proceedings 11, Philip L. Mossman, ed. (New York, 1996).

[21] This deterrent was not always successful. See *Coin World*, March 10, 1997, for an account of a hoard of struck counterfeit denarii of about 50 AD recently uncovered in England. See also Denis R. Cooper, *The Art and Craft of Coinmaking; A History of Minting Technology* (London, 1988), Chapter 2, for an excellent discussion of early cast coins.

proportions of silica, clay, and water, a mixture which also can be artificially made from these components.[22]

The finer the silica particles, the better the surface detail will be on the finished product, but it must be porous enough to permit the escape of gases as previously noted. The clay is the bonding component, usually 8-12% bentonite, which adds strength and plasticity to the mold.[23] The water, which activates the clay, must be carefully controlled at about 8%, since an excess, while favorably increasing the plasticity of the mold, will also reduce its strength. Also if a mold is too moist, when the molten metal hits, excess steam is produced, an important complication which will be discussed later. Too little water, equally as bad in another way, creates an undesirable non-cohesion of the clay and silica resulting in crumbling of the mold. When heated to the sintering point of 1050ºC, the clay, sand, and water become a coherent, imporous mass without melting,[24] but if any harmful minerals are included in the molding mixture, especially lime, these foreign substances usually will fuse from the localized action of the hot metal on the mold. The resultant conglomerate may adhere to the surface of the casting producing imperfections.

The inside surface of the mold is commonly coated with materials, usually powered graphite for bronze, which improves both the release of the casting and its surface finish. In addition, this coating material burns on contact with the molten metal, creating a fine protective film which prevents penetration of the hot metal.[25]

Molds may be dried after they are made but this additional step is not usually necessary.[26] Molds must be gated, a term which describes the provision of easy access of molten metal into the mold cavity through a series of openings, runners, and channels. See Figure 1 on the following page. Since the natural permeability of molding sand is inadequate for the escape of all the hot gases, additional vents are necessary. These gases come from the air in the mold cavity, the steam from the hot metal action on the moist sand, and the reaction of the liquid metal on the mold coating material or any organic material entrapped in the sand.[27] If venting is inadequate, then the upper surface of the casting, in particular, will show little voids from the effect of the retained gas bubbles. Escaping steam can injure the mold by blowing off a portion of the sand mold face forming a "scab."[28] Since most of the impurities in molten metal have a lower specific gravity, these tend to float on the top of the molten mixture and do not enter the mold itself.[29]

B. The Molten Metal

As the molten metal cools, it solidifies or “freezes.” A pure metal has a specific freezing point whereas an alloy freezes over a broader temperature range. Solidification starts at the surface of the casting and proceeds centrally. Since solid metal is denser than its liquid state, contraction, or shrinkage, occurs with cooling, a situation just the opposite from freezing water. The cooled,

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[22] S. E. Rusinoff, *Foundry Practices* (Chicago, 1955), pp. 26,28; Richard W. Heine, Carl R. Loper, Jr., Philip C. Rosenthal, *Principles of Metal Casting*, 2nd ed. (New York, 1967), pp. 84, 85, 116. A. J. Murphy, editor, *Non-Ferrous Foundry Metallurgy* (London, 1954), p.2.

[23] Rusinoff, *op. cit*., p. 29; Heine *et al*., *op. cit*., pp. 2, 3, 86, 87, 88.

[24] Heine *et al.*, *op. cit*., p. 116.

[25] Rusinoff, *op. cit*., p.44; Heine *et al*., *op. cit*., pp. 90, 120.

[26] Rusinoff, *op. cit*., p. 14.

[27] Rusinoff, *op. cit*., p. 50.

[28] Heine *et al.*. *op. cit*., p. 177.

[29] Rusinoff, *op. cit*., p. 52.

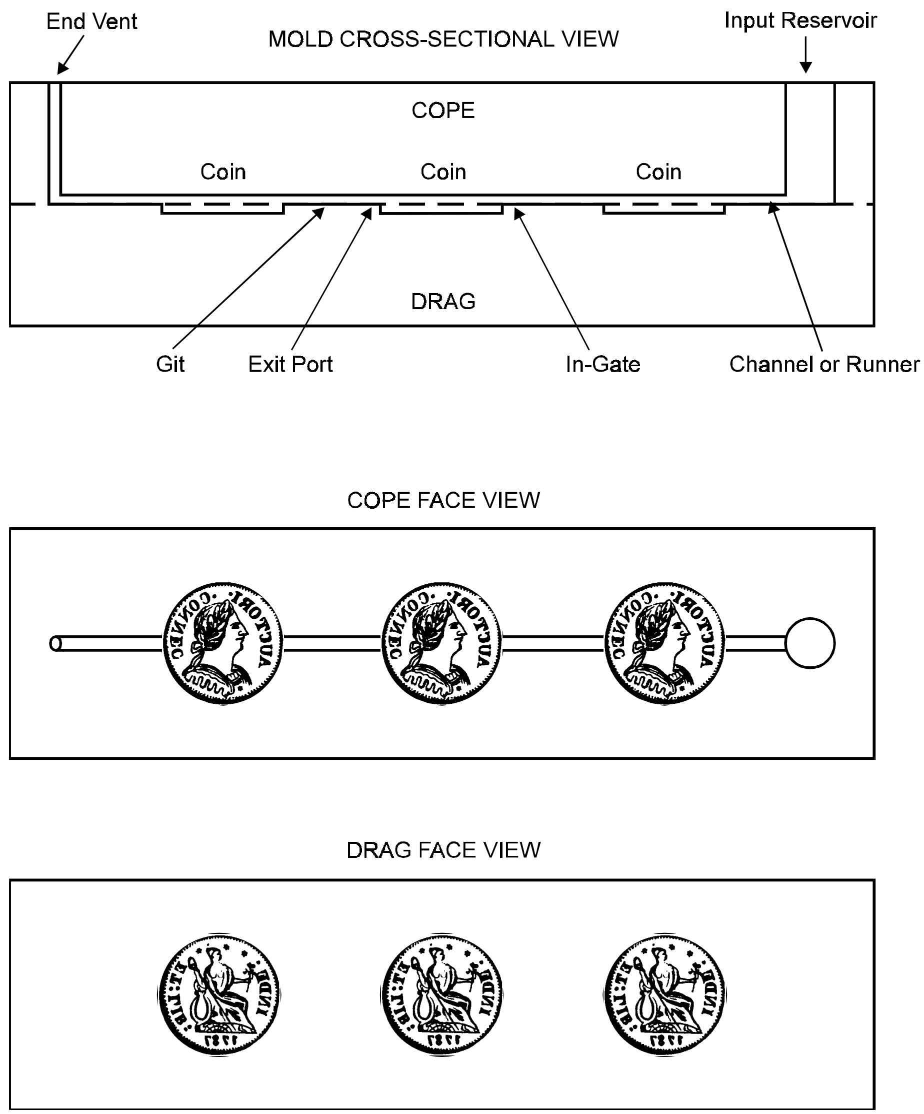

Figure 1
Views of proposed mold layout and gating system for casting three coins in series, or *en chaplet*, consistent with 18th century casting technology.

Figure 1 Definitions

Gate: The channel system through which molten metal flows into the mold, and also, the plug of waste metal in the gate opening after the metal solidifies.

Runner or Channel: The specific trough for conducting the molten metal into the interior of the mold.

Git: A smaller channel entering the coin mold leading from the larger runner, especially in the parallel casting format.

Cope: Top half of the mold.

Drag: Bottom half of the mold.

In-Gate: Where the flow of the molten metal enters the mold.

Exit Port: Where the flow of the molten metal exits the mold en route to the next mold [here pictured] or the end vent.

denser casting will pull away from the edges of the mold,[30] but if molten metal is continually supplied to the mold during this solidification process to compensate for such a loss, the shrinkage is lessened. For pure copper, the uncompensated shrinkage on cooling is about 4%. As solidification proceeds at the surface, cooling starts in the center, with resultant shrinkage as the metal becomes more dense. This produces a "pasty zone" of hardening metal in the interior core of the casting characterized by the appearance of small voids and channels. This phenomenon, termed "shrinkage microporosity," is greatly increased when the alloy has a wide freezing range.

C. Microporosity

The solubility of gases is less in solid metal than in the liquid state, another situation opposite from water. These entrapped gases, hydrogen, oxygen, sulfur dioxide and water vapor, which had become dissolved in the molten metal during the smelting process, come out of solution as the metal solidifies, and become the second cause for microporosity during the cooling process, or "gas unsoundness." Microporosity is particularly evident in alloys with a long freezing range, such as tin bronzes and gunmetal.[31] It is difficult to distinguish between microporosity from gas separation and localized shrinkage since the irregularly formed voids seen in each instance are essentially identical. Microporosity, from any cause, will reduce the specific gravity of the cast object.

Coinage Casting Techniques

We will follow the description of the casting process for coins as related by Mason who begins with the ancient Roman method where patterns were pressed into disc-shaped clay molds, obverse on one face and reverse on the other, and then heat-hardened by baking.[32] The patterns were removed, the discs clamped together, and a channel cut into them to admit the molten metal into the hollow interior of the joined halves of the mold. By the 18th century, two basic methods for multiple coin casting appear to have been in use.

> ... two slabs of clay were used, one with the impression of the obverses and the other with the reverses. The metal was allowed to flow from one impression to the next through a channel cut in the clay, the result resembling a string of beads, the coins being the beads and the metal from the channel between them, the string. [It was parenthetically noted that this method was used in making the Manx coins of 1709.]

The second method was a parallel casting process.

> In the more modern method the ordinary sand mould was used, split in a direction parallel to the faces of the coins. One half of the mould for the obverses and the other for the reverses of a number of coins. In this case a deep channel or "runner" was cut between every pair of rows, with narrower shallower channels or "gits" cut at right angles from the runner to the impression of the coins. By this method, the hot metal ran quickly down the runners to the far ends and was feeding the end impressions before the first were full, or in other words all the impressions were filled more or less at the same time. As these gits could not be thicker than the coin and would be rather less than a quarter of an inch wide, in the string method, sometimes referred to as "en chapelet,"[33] the

[30] Heine *et al.*, *op. cit.*, p.192; Heine *et al.*, *op. cit.*, p. 53.

[31] W. A. Baker, "Casting Alloys," Copper-base Alloys, in A. J. Murphy, editor, *Non-Ferrous Foundry Metallurgy* (London, 1954) p. 358.

[32] C. L. Mason, "Making Coins," *Seaby's Coin and Medal Bulletin*, Mar. 1948, #358, pp. 101-102.

[33] *Le chapelet*, a string of beads, hence, a Rosary.

metal was apt to get sluggish and not fill the moulds properly and finally freeze completely before it reached the furthest mould.[34]

There are several variations to the casting process which differ as to "how the mold is made and in how the metal is forced into the mold,"[35] including the "lost wax" process (*cire-perdue*) or investment casting, an ancient method dating from the about third century BC. Since it is unlikely that the coppers in this study were made by that method, this technique will not be described herein.

Even though excellent copies of coins can be made by casting, the product is far from perfect since every step of the method can leave its tell-tale signs. The remainder of this section will be devoted to the characteristics which help identify cast counterfeit regal and Confederation coppers made by either the series (*en chapelet)* or the parallel casting technique.[36]

A. Copper and Copper Alloys:

To produce a struck copper coin, the purity of the copper is kept rather high. Even in the case of struck counterfeit coins, studies have shown that the copper used was normally better than 95% pure.[37] Since most metal additives to copper produce alloys harder and more brittle than copper, to reduce the tendency for splitting and delamination during rolling and to facilitate successful striking, copper was kept rather pure.[38] When Sir Isaac Newton was appointed master of the Tower Mint in December 1699, to insure a directive that only pure copper be used for coining, he employed a simple test.[39] When pure copper is heated red hot, placed on an anvil and beaten with a hammer, it will not crack, whereas, if alloyed with tin, lead or zinc, it will split. This test was used to accept or reject copper delivered from the smelters contracted by the Tower Mint. Blister copper, straight from the smelter would have been sufficiently pure, without further processing.[40]

In the case of cast counterfeit coppers almost any metal or mix of metals that would alloy with copper seems to have been used. This is because the quality of the cast coin depends primarily on the quality of the mold and only secondarily on the quality of copper used. Thus one finds cast counterfeit halfpence ranging from bright yellow brass to dark gray-brown lead bronze.

We have used X-ray fluorescence spectroscopy, a non-destructive technique, to analyze the metallic composition of several cast counterfeit coins, as well as a representative set of legally struck coins they imitate. A description of the measuring equipment, its calibration, and the analysis procedure are discussed in Appendix B.* The results of these determinations are presented in the comments column of the study collection listing. Substantial quantities of tin, lead, zinc and/or iron are routinely found with copper in cast coins. Although it is true that some of those metals produce alloys with copper with somewhat reduced melting temperatures (perhaps resulting in a modest fuel savings to the counterfeiter) or a reduced viscosity (a flow advantage in the casting process), what emerges from our composition measurements is the conclusion that there was no clear pattern to alloy preference. It appears that using whatever materials were on

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34 We have no indication if the molds were heated which would facilitate metal flow.

35 Britannica CD 2.0 (1965).

36 See also Richard Doty, *The Macmillan Encyclopedic Dictionary of Numismatics* (New York, 1982), pp. 48-50.

37 Smith, *op cit.*

38 S. L. Archbutt and W.E.Prytherch, "Effects of Impurities in Copper," *British Non-Ferrous Metals Research Association, Research Monograph No. 4* (1937).

39 Craig, *op cit*, p. 220.

40 R. W. Ruddle, *The Physical Chemistry of Smelting*, Institute of Mining and Metallurgy (London, 1953)

*** Appendix B is on page 1803.**

hand, no doubt from scrap or black-market sources, was the prevailing practice.[41] The major constituent was always copper, in order to yield the expected look, but beyond that, the *soupe-du-jour* was poured into the mouth of the coin mold.

B. Weight:

The weight of an individual suspect coin is useful as a counterfeit diagnostic only when it can be compared to the average weight and standard deviation for the legal population of the coins it imitates. The weight specification for early coppers was for a specified weight per batch of coins, expressed by the number struck per pound of metal, and not a "per individual coin" requirement. Thus, one finds a broad weight distribution even for well supervised mint production. The problem in making weight comparisons is that the light end of the weight distribution curve for legal coins can overlap into the range for the heavy end of the weight distribution of counterfeit coins, even though "on average" the counterfeit coins are lighter than their legal counterparts. Post production factors can also change the weight of a coin. Both the wear from the stresses of circulation and the damage and porosity suffered from burial in the ground for extended time can diminish the weight of a coin. In the case of cast counterfeit coppers, since the density of lead bronze can be substantially greater than the density of brass or tin bronze, certain cast counterfeit coins can equal the weight of their legal patterns. Therefore, weight, as a single diagnostic, must be correlated with the other properties of a suspect coin, such as diameter, specific gravity, and design definition in order to build a case for genuineness or forgery.

Weight and size averages and distributions can be found in Peck for regal English coppers, in Mossman for state coppers and Fugios, and in Smith for struck counterfeit English George III halfpence. Smith (to be published) has also compiled weight and size averages with distribution curves for legal and counterfeit George III Irish halfpence.

C. Specific Gravity:

Specific gravity is the ratio of the mass of an object to the mass of an equal volume of a standard substance, usually distilled water. Specific gravity, as used in numismatic research, is a non-destructive technique for estimating alloy composition when the constituent metals of the alloy are known. Although quantitative only in cases of binary alloys (i.e. two metals), it is useful, for example, to estimate the ratio of gold to silver in an electrum coin.[42] In the case of cast coppers, it is merely a general guide, since most alloys used, were composed of three or more metals.

The measurement of specific gravity is, in principle, a simple measurement. First one determines the coin's dry weight in air and next it is weighed while completely suspended in water on a thin thread, taking great care to eliminate any adherent air bubbles. The ratio of the dry weight to the difference between the dry weight and the wet weight is the specific gravity. Correction for the weight of the device used to suspend the coin in water must be made.

Even when the measurement of specific gravity is carefully carried out using proper equipment, there are complications associated with simple cast coins that can yield spurious results. When molten metal is poured into a mold, gravity drives the metal flow while viscosity and hot gases impede it, thus solidification can occur in a rather dynamic environment. As discussed, one

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[41] See Charles W. Smith, "The Annotated Halfpenny," *CNL*, pp. 1718-19, 1725-26.

[42] W.A. Oddy and M.J. Hugh, "The Specific Gravity Methods for the Analysis of Gold Coins," in E.T. Hall and D. M. Metcalf, editors, *Methods of Chemical and Metallurgical Investigation of Ancient Coinage*, Royal Numismatic Society, Special Publication Number (London, 1972), pp. 75-87.

consequence of this environment is the possible incorporation of trapped gases in the cast coin in the form of voids that do not reach the surface and/or channels that do. The presence of voids and/or channels distorts both the dry and wet weights with the overall tendency to reduce the specific gravity result to a value less than it would have been absent these complicating processes. Coin #70 in the Study Collection (Appendix A)* list, a 1787 Connecticut M. 1.1-A, illustrates this effect. The specific gravity of this example is 7.86, substantially less than that of pure copper (8.92), yet it is 21.5% lead! Thus for several reasons, specific gravity of a cast coin does not directly imply composition, however, an inappropriate specific value can help build a case against genuineness.

With these qualifications in mind, we have listed the specific gravity values for each of the cast coins in the study collection. As a point of reference, the values for the specific gravities of copper, tin, lead, zinc, iron and two standard coppers alloys are listed below.

MATERIAL	SPECIFIC GRAVITY
copper	8.92
tin	7.31
lead	11.34
zinc	7.14
iron	7.86
bronze 932[43]	8.99
brass 260[44]	8.57

Table I: Specific Gravity of some common metals and alloys.

D: Diameter and Shape:

The natural density increase that accompanies the solidification of metal may be responsible for some cast coins being smaller than the parent coin from which the mold impression was taken. Another influence on diameter is the reduction in size occasioned by the need to "dress" the edge of a cast coin, usually by filing and/or hammering. This edge treatment is necessary since a cast coin as removed from the mold, has rough edges, not only where it was separated from the in-gate flow channel, but also at the gas vent hole and around the circumferential mold seam where the top half of the mold (the cope) joins the bottom half (the drag). These irregularities must be reduced for the edge of the cast coin to resemble more closely the edge of a legal coin, struck on a punched flan. This edge dressing not only decreases the average diameter of the coin, but, because the smoothing is more aggressive near the in-gate and vent hole, the cast coin will generally be out-of-round. Additionally, cast coppers were produced from a mold taken by pressing a struck legal coin into the molding sand. This coin itself, struck without a collar, will be out-of-round as well, as will be, of course, its sand impression. Given the above circumstances, it is not surprising that cast copper counterfeits are generally smaller than the coin they imitate and are almost never round. These features are often very helpful in the identification of such counterfeits.

[43] Bronze 932 is a specific alloy of 83.0% Cu, 7.0% Sn, 7.0% Pb, and 3.0% Zn.

[44] Brass 260 is a specific alloy of 70.0% Cu and 30.0% Zn.

*** Appendix A starts on page 1789.**

E. Surface Morphology:

Mason notes that the field of a cast piece in good condition still *lacks the brilliancy of a struck coin*, and may have *quite a rough appearance*. Even on pristine cast copies, the surface condition, typical of a struck coin, will of course be absent. The devices of a struck coin are impressed into the planchets under high pressure which work-hardens the copper and flattens out the fields. This results in what has come to be called hard and lustrous fields, for a well struck coin. On the other hand, sand cast coins are subject only to the forces of gravity and flow, which create the entire coin in a low pressure environment. These manufacturing differences between struck and cast coins are evident in the surface morphology of the final products.

For example, a depression flaw in the surface of the sand mold, which has been filled by metal, will cause an elevation on the cast coin referred to in the trade as a “pimple.” As a corollary, any gas trapped in the mold can cause a bubble at the surface resulting in a surface depressions on the cast coin. The surface of a cast coin can thus be pitted, bumpy, wavy, etc.

F. Device and Lettering Resolution:

In the same way that fields in a cast specimen will differ from its parent coin, so will the devices and lettering lack smoothness and resolution. The casting process depends upon the flow of molten metal to fill all the recesses of the mold. The devices transferred to the mold are naturally blunted since one cannot expect to replicate the same level of detail from the parent coin from a sand impression. *In extracting the pattern from a sand mould, the grains are apt to stick in the letters, especially in such places as the upper triangle of an “A” or in the* [loops of the] *letters B, P, and R if the sand has pulled away from the centre of a letter, the molten metal takes its place and gives a correspondingly rough appearance.*[45] The letters acquire a “filled in” appearance.

G. Edge Marks:

Edge examination of a cast coin is most revealing because this is the site of the casting port, where the git was attached to the coin, the gas vent location, and the seam where the mold halves join. These technological artifacts may be seen on one side of the coin or both. In serially casted coins, there will be two similarly sized ports about 180° from each other, whereas in a parallel casting technique, there is the entrance of the single in-gate with a smaller gas vent hole, which can be at any angle with respect to the in-gate. It is obvious that such ports are necessary for each mold chamber in the parallel system and at the end of the line in the series method. As Mason explains,

> Whichever method was used, after the metal had cooled, the castings were removed from the molding box and the gits sheared off level with and tangential to the circular edges of the coins. Even if sheared off square, this necessarily left two sharp corners on each side of the git which afterwards had to make a circular edge. This frequently done very carelessly, so that on a cast coin, provided it had not been in circulation too long, the place where the git was, can often clearly be seen. On a coin which has seen much wear, however, the edges are no longer sharp and the remains of the git become worn flush, in which case one can no longer decide by that means whether the coin was cast or struck. If on the other hand, the git is cut off too short, a flat place is left on the edge of the coin.

Since the coin mold is formed from two halves held together, metal may flow into this union forming a thin, irregular tab known as a flash, either partially or completely around the circumference of

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[45] Mason, *op. cit.*

the coin. Thus, there were two incriminating signs on the coin's edge which had to be removed, the remnant of the casting port(s) and possible gas vent, and any excess metal which had leaked out between the opposing halves of the mold. File marks are telltale indicators of a cast coin and may be seen perpendicular or tangential to the coin's edge. They are particularly evident where the git has been severed, but since they may be obliterated with wear, file marks are not seen on all cast coins. There are of course other complications. The edge of a struck coin can be abraded in circulation in such a way that produces marks that may resemble those caused by a file. In addition, the edge of a well circulated cast coin may be smooth, whereas a well preserved struck coin, whose planchet has been cut from a strip of metal, will show the striations of the punching process. Electrotype counterfeit coins can show an edge seam and filing marks. And in the hybrid case of William III coppers where coins were struck on cast planchets, one observes the characteristics of the devices and lettering of a properly struck coin in combination with the edge indications of a cast planchet.

How frequently can one expect to find telltale signs on cast coins? This can be answered in part by examining coins which are known to have been cast, such as a population of Chinese cash. Two hundred and forty-six cash, dating from 1662 to 1850, were examined for signs of casting with the following number of occurrences:

Ingate site still evident	= 15.4%
Marks of mold around edge	= 6.5%
Surface defects, pimples and voids	= 6.1%
Hole in coin [other than central hole]	= 4.1%
Cracked	= 0.8% [these cracks would have fractured the coins in two pieces, had not the fissure stopped at the central hole]

Table II: Percentage of Casting Flaws Evident in a Population of 246 Cast Chinese Cash.

A single defect was seen in 25.2% of the series, whereas, multiple defects were seen in 4.1%.

Confederation Coppers

We know of no existing records which indicate the exact technique used to make cast counterfeit Confederation coppers. Our understanding of the contemporaneous technologies employed has to be gleaned from examination of the coins themselves. It is likely that these coppers came from several independent sources and there is no reason to expect that the same production techniques were consistently employed. What is true is that casting required far fewer and more simple technologies than striking, wherever it was done. We do not know if it was common practice to cast counterfeit coins singly, or multiply, and if multiply, if they were cast *en chapelet* or in parallel. We do not know how many times one mold could be reused. What we do know is that virtually every Confederation copper series was counterfeited by casting.

From the many non-struck counterfeit coins (including a few electrotypes) we had the opportunity to examine, we selected 100 examples of Confederation period coppers that were clearly cast,

and, in our opinion, counterfeited with the intent to pass as currency. All are common varieties except for two Rarity 6s and five Rarity 5s, but these seven are so crude it is unlikely that any were made at a later time specifically to dupe collectors of numismatic rarities. We evaluated other coins, which, by their very nature, could have been made at a later time and were thus excluded, but still we can make no guarantee that some more modern cast forgeries may have escaped our detection. Among this group was a cast 1723 Rosa Americana twopence since it could be argued that there was little incentive to make a contemporary counterfeit of such an unpopular series with an already troubled circulation. We also omitted a pre-dated 1783 Military Bust Washington, some 1787 Immunis Columbia pattern pieces, a Voci Populi token, and a 1794 Talbot, Allum and Lee token due to the likelihood that they were cast after the period under consideration and were not intended for parallel circulation with their legitimate counterparts. We will describe each of the 100 selected examples in regard to the seven physical and visual characteristics described in the previous sections (items A through G) and present some remarks regarding production techniques.

The Study Collection

For the purposes of technical analysis, we have assembled, from three private collections, a group of 100 18th century cast counterfeit coppers of the types that could have circulated in pre-Federal British North America.[46] We refer to this group of coins throughout the paper as The Study Collection. Although no attempt at a rigorous statistical presentation is claimed, it is interesting to note that English and Irish coppers of George I, George II, and George III are represented by 41 examples, while state coppers of Connecticut (32 examples), New Jersey (15 examples), Massachusetts (3 examples), New York (3 examples), and Vermont (2 examples) comprise the bulk of the study collection.

The following quantitative measurements were carried out on all the specimens in the study collection: weight, vertical diameter, horizontal diameter, and specific gravity. For 22 examples, elemental composition analysis, using x-ray fluorescence spectroscopy was made. In addition, all 100 examples were qualitatively assessed as to clarity of the lettering and devices (excellent 100%, fine 75%, good 50%, fair 25%, and poor for less than 25% legibility), edge condition (smooth, filed, hammered, and irregular), and finally surface (fields) texture (smooth, grainy, pitted, pimples, wavy, and lumpy).

In almost every case, one or both of the casting ports left a tell-tale mark at the edge of the cast coin. The locations of these marks for each coin are specified by the nearest clock face hour position with respect to the coin obverse, i.e. up and down specified as K-12 and K-6, while left and right are K-9 and K-3, etc. Occasional comments as to color and general state of preservation and wear are also noted in our attempt to describe each example.

Concluding Remarks

- Connecticut and New Jersey examples comprise the vast majority of state coppers that were counterfeited by casting.

- Cast coppers are, on average, lighter in weight than the coins they imitate and slightly smaller in diameter. They also tend to be more out of round than struck examples because of the need to dress the coin edge by filing or hammering.

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[46] We wish to thank Mike Ringo for the loan of cast counterfeit coppers from his personal collection for inclusion in our study. Likewise, we are indebted to The Colonial Newsletter Foundation for allowing us to use cast counterfeit examples from the Edward R. Barnsley reference collection of Connecticut coppers.

- There appears to be no clearly preferred alloy composition but in all cases measured, copper was the major component often followed by lead, tin, and infrequently zinc in that order. Occasionally iron was incorporated in the alloy perhaps as a contaminant from the crucible in which the metal mixture was melted. It should be noted that most examples are lead bronzes with some tin, or tin bronzes with some lead, and only rarely brass.

- Coins were cast in sand molds, probably in groups as well as singly.

- In instances where both the casting port and gas vent, or exit port, can be located, there was a distinct preference for the ports to be 180º apart for the English and Irish coins, whereas the distribution curve for the angle of separation between the two ports for the state coppers, was much flatter, with only a moderate preference for the 90º and 180º spacing. This seems to indicate a preference in England and Ireland for a series, or *en chapelet*, casting geometry, whereas for state coppers, evidence for this configuration is less persuasive.

- In England, during the last half of the 18th century, with the advent of the Industrial Revolution, casting of coppers was replaced by mechanized striking technologies. In pre-Federal America, that transition seems to have occurred 30 to 40 years later, and during this interval both casting and striking technologies were employed. The large capital costs for equipment and the skills needed for die cutting, kept counterfeiting of coppers a small scale casting "cottage industry," with the notable exception of Machin's Mills, and those coiners associated with the other mass produced struck contemporaneous counterfeits such as the common 1787 Connecticut Miller 4-L (the "horned bust"), the New Jersey Maris 54-k (the "serpent head" of the elusive Mr. Hatfield) and the prolific New Jersey Maris 56-n, to recall but a few.

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Acknowledgment

We would like to express our appreciation to Michael Hodder for his review of the manuscript and his helpful suggestions.

APPENDIX A

The Study Collection

Notation Key

- **ID# =** sequential number, 1 to 100.
- * in the ID# column indicates the example is illustrated with discussion.
- **Coin Type**: Unless otherwise specified, all English and Irish coins are halfpence.
- **Weight** = Weight in grains.
- **Sp. Gr.** = Specific Gravity relative to distilled water.
- **Vert. Dia.** = Vertical Diameter in mm., obverse vertical.
- **Horz. Dia.** = Horizontal Diameter in mm., obverse horizontal.
- **R** = Resolution of devices and lettering: 100, 75, 50, 25, and less than 25% legible.
- **E** = Edges: **s** = smooth, **f** = filed, **i** = irregular, **h** = hammered, **m** = circumferential mold mark.
- **S** = Surface texture, primarily the fields: **s** = smooth, **g** = grainy, **pt** = pitted, **pp** = pimples, **w** = wavy, **l** = lumps
- **C** = Cast port location(s) by nearest clock hour angle.
- **Comments**: elemental analysis, when done, will be listed here: % Cu = copper, % Pb = lead, % Sn = tin, % Zn = zinc, and % Fe = iron.

ID #	Coin Type Date Dies	Weight Sp. Gr.	Vert Dia. Horz. Dia.	R	E	S	C	Comments
1	George I 1/4d. 1720 England	36.1 8.60	21.2 21.6	75	m	pt	5 11	m = mold rim marks
2 *	George I 1721 England	112.7 8.60	--- 27.5	50	f	pt l	6	filled lettering
3	George II; young head England	155.0 8.56	26.6 27.2	50	f	pt s	7 12	
4	George II; young head England	105.6 6.68	27.2 27.9	<25	---	pt	5	porous; unusually low sp. gr. = voids
5	George II 1730 England	125.4 9.02	26.4 27.6	<25	f	g	6	yellowish color; graffito XXXIII; 70.1%Cu, 11.1% Pb, 18.7% Sn
6	George II 1730 England	106.9 8.69	26.9 27.0	50	i	pt w	5 7	
7	George II 1735 England	99.9 7.19	27.4 27.9	25	f s	g	4 10	
8	George II 1736 England	108.9 8.51	26.9 27.5	75	i	w	2 11	
9	George II 1737 England	155.0 8.38	27.4 28.6	75	f	pt g, l	1 6	91.3% Cu, 5.0% Pb, 3.7% Sn
10	George II 1737 England	108.8 8.70	27.4 27.7	50	s	pt w	6 11	
11	George II 1738 England	130.8 8.78	27.0 28.0	50	f	s	5 11	
12	George II 1738 England	95.1 7.55	27.0 27.6	50	s	g	7	low sp. gr.; 98.2% Cu, 0.9% Pb, 0.9% Sn
13	George II 1739 England	121.8 8.76	--- 28.0	50	s	pt	6 12	
14	George II 1739 England	132.8 8.15	27.0 27.3	100	f	g	6	97.5% Cu, 2.4% Pb, 0.1% Sn

ID #	Coin Type Date Dies	Weight Sp. Gr.	Vert Dia. Horz. Dia.	R	E	S	C	Comments
15	George II 1739 England	104.8 8.52	26.5 27.2	50	s	s	2	
16	George II 1739 England	118.6 8.79	26.4 27.3	<25	m	pt w	2 8	
17	George II 1739 England	113.4 7.26	27.2 28.2	50 25	m	s l	6	
18	George II 1740 England	146.0 8.74	27.9 28.2	100	s	pt	---	
19 *	George II 1740 England	156.2 8.54	26.8 27.2	25	f	pt g, l	5 11	Pinocchio nose; 66.2% Cu, 4.7% Pb, 3.2% Sn, 25.9% Zn
20	George II 1744 England	101.0 8.94	26.3 26.9	50 25	s i	l	8	
21	George II 1745 England	134.0 8.54	27.6 28.1	50	f	g	9	
22	George II 1746 England	124.6 8.77	27.4 28.2	50	s	s	7	
23	George II 1746 England	104.1 8.46	26.5 26.9	25 25	f	g	12	circumferential mold seam
24	George II 1746 England	133.3 8.77	27.3 27.8	100	s	pt	12	
25	George II 1748 England	115.1 8.46	27.4 27.9	25	s	pt w	2	95.3% Cu, 1.4% Pb, 3.3% Sn
26 *	George II 1750 England	140.1 8.65	27.4 27.3	100	f	s l	1 7	"state-of-the-art"
27	George II 1751 England	102.7 7.78	27.3 27.5	100	i	g w	1 7	filled letters on the reverse
28	George II 1752 England	110.6 8.57	27.5 28.0	100	f	g	2	
29	George II 1753 England	121.9 8.9	27.9 28.2	100	f	s	3 11	
30 *	George II 1754 England	165.5 8.71	27.4 27.4	50	tab	pt	3 11	mold edge-tab; heavy
31	George III 1771 England	139.5 8.89	28.8 29.2	75	h	s w	8	thick
32 *	George III 1772 England	124.3 8.69	27.9 28.1	50	f	pt pp	7 11	cast copy of struck counterfeit
33 *	George III 1775 England	172.8 8.91	27.3 27.4	25	f	pt	3 9	cast copy of struck counterfeit; heavy; 82.9% Cu, 12.0% Pb, 5.1% Sn
34	George II 1742 Ireland	106.8 8.61	26.1 26.6	50	f	pt	3 9	
35	George II 1742 Ireland	98.5 8.64	26.1 26.6	75	f	pt g, l	4 10	cast from a struck counterfeit
36	George II 1760 Ireland	92.1 8.61	25.6 26.0	50	f	g	6 12	86.9% Cu, 4.4% Pb, 3.0% Sn, 1.0% Fe
37	George III 1766 Ireland	114.6 8.70	26.9 27.0	75	i	g	4 8	
38	George III 1781 Ireland	134.2 8.84	28.2 28.5	100	s	g pt	3	

ID #	Coin Type Date Dies	Weight Sp. Gr.	Vert Dia. Horz. Dia.	R	E	S	C	Comments
39	George III 1781 Ireland	90.9 8.90	26.9 26.8	75	f	g	4 11	
40	George III 1782 Ireland	98.5 8.95	26.2 26.7	75 100	i	g pt	2 8	filled letters
41 *	George III 1783 Ireland	78.4 8.52	26.4 27.6	50	f	pt g	8	cast copy 5% off-strike counterfeit; light; 91.8% Cu, 4.4% Pb; 0.8% Sn, 3.0% Fe
42	French Colonies 1767 A	32.4 8.76	22.2 22.6	50	s	s	8	
43	1787 Fugio Newman 21-I	137.9 8.84	28.2 28.2	50	s	g	1 4	
44 *	Nova Constellatio 1785 Crosby 2-A	100.9 8.85	26.7 26.5	75 50	f	pt l	8	
45	Nova Constellatio 1785 Crosby 3-B	94.4 8.92	26.4 27.0	50	s	pt g	4 8	
46 *	Nova Eborac 1787 rev. fig. left	100.4 8.90	25.9 26.3	25	f	pt l	4 11	78.8% Cu, 12.8% Pb, 8.4% Sn
47 *	Nova Eborac 1787 rev. fig. left	90.0 8.91	26.8 27.3	25	f	pp l	1 8	
48	Nova Eborac 1787 rev. fig. left	125.0 8.56	26.2 27.3	50	i	g	11	
49	Vermont 1787 RR-13	104.0 8.74	27.0 27.0	25 <25	i	g	1 7	
50 *	Vermont 1787 RR-27	78.7 8.74	26.6 26.6	75	f	pt	3 7	89.5% Cu, 5.0% Pb, 5.0% Sn, 0.5% Fe
51 *	Massachusetts	146.5 8.01	29.3 29.5	<25	i	l	4	97.8% Cu, 0.7% Pb, 1.5% Sn
52	Massachusetts 1788 2-B	137.7 8.56	28.2 28.2	75	f i	g	10	filled lettering; filed K-9 to K-11
53	Massachusetts 1788 3-A	141.3 8.63	27.7 27.8	<25	f	g	12	
54 *	Connecticut 1785 3.3-F.3	111.0 8.81	26.9 27.7	75 <25	s	g	4 12	fine obv.; poor rev.
55	Connecticut 1785 3.3-F.3	119.1 8.69	27.1 27.6	75 o: 25 r:	s	pt g	3 6	or 6.4-F.5
56	Connecticut 1785 4.3-A.2	127.9 9.01	27.4 27.2	50	s	pt g	7 11	
57	Connecticut 1785 5-F.5	122.2 8.67	27.5 27.7	50	s	pt	9	
58 *	Connecticut 1785 5-F.5	126.0 8.57	27.9 28.3	75	s	g	10	broken in half; piece missing; not full weight
59	Connecticut 1785 6.3-G.1	136.6 8.70	28.6 28.3	50	s	s l	---	
60	Connecticut bust left	84.5 8.90	25.2 24.5	<25	s	s	7	small
61	Connecticut bust left	122.1 8.91	26.9 27.4	25	i	pt g	2 8	
62	Connecticut bust left	84.8 8.32	26.4 27.0	<25	i	pt	4	
63	Connecticut 1786 bust left	120.8 8.51	--- 27.3	<25	i	pt g	3 11	filled letters

ID #	Coin Type Date Dies	Weight Sp. Gr.	Vert Dia. Horz. Dia.	R	E	S	C	Comments
64	Connecticut 1786 3-D.1	81.2 8.92	26.9 26.1	50	i	pt w	4 7	
65	Connecticut 1786 5.4-G	118.8 8.55	27.5 27.4	75	s	g	9	89.9% Cu, 9.1% Pb, 1.0% Fe
66 *	Connecticut 1786 5.4-G	148.0 8.81	28.1 28.3	75	i s	l	1 11	98.3% Cu, 1.2% Pb, 0.5% Sn
67	Connecticut 1786 5.7-H.1	143.5 8.86	28.4 28.2	75 50	s	pp l	5	parent coin [270°] 5% off strike
68	Connecticut 1786 5.10-P	168.5 8.92	28.4 28.2	<25	s	l	11 to 4	heavy
69	Connecticut 1787 bust left	114.2 8.79	27.0 28.0	25	s i	pt	3 9	
70	Connecticut 1787 1.1-A	99.8 7.86	26.0 26.5	25	i	pt	6	low sp. gr.; 74.5% Cu, 21.5% Pb, 4.0% Sn
71	Connecticut 1785 5-F.5	123.6 8.77	27.1 27.3	50 50	f	pt	3	
72	Connecticut 178711.1-E	102.5 8.76	27.7 27.8	50 <25	s	pt g	8	sides look very different; 95.1% Cu, 21.5% Pb, 0.5% Sn
73	Connecticut 1787 11.1-E	124.3 8.94	27.5 27.7	25	i	g	8 12	
74	Connecticut 1787 26-AA	111.9 8.11	27.2 27.6	75 <25	f	g	4 11	93.5% Cu, 4.9% Pb, 1.1% Sn, 0.5% Fe
75	Connecticut 1787 26-AA	117.8 8.79	27.2 27.3	50 <25	f	g	12	
76	Connecticut 1787 32.3-X.4	78.1 8.98	27.1 26.9	50	f	l	7 10	light, thin
77	Connecticut 1787 33-Z	121.7 8.69	27.4 27.8	75	f	g	8	
78 *	Connecticut 1787 33.6-kk	135.9 8.88	27.7 26.5	100	f	g	5 10	"engrailed edge"
79	Connecticut 1787 33.6-kk	110.9 8.94	26.9 26.4	50	i f	g l	5 8	
80	Connecticut 1787 33.7-r.2	108.9 9.00	27.4 27.7	50	s	pt g	2 9	
81	Connecticut 1787 33.37-Z.9	129.7 8.82	27.0 27.6	50	s	pt g	1	
82	Connecticut 1787 43-Y	115.9 8.92	27.5 27.6	100	i	g	6 12	
83	Connecticut 1788 2-D	113.8 8.96	26.8 27.1	75	s	pt g	7	
84	Connecticut 1788 15.1-L.1	124.1 8.62	27.1 –-	<25	f	l	5 11	defaced; not full weight
85	Connecticut 1788 16.1-D	101.3 8.89	26.5 26.1	25	s	s	1 11	surface blotches without detail
86	New Jersey 1786 14-J	113.3 8.46	27.2 27.3	75	s	g	6 9	20° die rotation
87	New Jersey 1786 17-b	108.4 9.03	29.8 30.3	50 100	f	g	3 9	
88	New Jersey 1786 18-M	136.0 9.01	27.7 27.7	75	s	g	–-	bulge at plow

ID #	Coin Type Date Dies	Weight Sp. Gr.	Vert Dia. Horz. Dia.	R	E	S	C	Comments
89	New Jersey 1786 19-M	157.9 9.02	28.3 28.5	50	s	pt	---	
90	New Jersey 1786 21-N	123.1 9.05	26.7 27.2	75	i	g	5 7	
91	New Jersey 1786 21-P	113.7 8.81	27.1 27.0	50	s	pt g	11	
92 *	New Jersey 1786 23-R	143.7 8.93	26.8 27.6	50	i	pt g	1	77.7% Cu, 12.3% Pb, 10.0% Sn
93	New Jersey 1786 23-R	108.1 8.45	26.7 27.0	75	i f	pt g	10 12	
94 *	New Jersey 1786 32-T	131.0 8.19	27.0 26.9	75	s	s	2 4	95.8% Cu, 1.9% Pb, 2.3% Sn
95	New Jersey 1787 52-i	125.0 8.39	27.1 27.4	100	i f	pt	12	92.8% Cu, 4.2% Pb, 2.5% Sn, 0.5% Fe
96	New Jersey 1787 52-i	105.1 8.84	27.0 27.1	75 25	s	s	10	[340° die rotation]; sides look very different
97	New Jersey 1787 54-k	100.1 9.02	27.2 27.0	25	s	g	4	
98 *	New Jersey 1787 56-n	107.2 8.58	28.5 28.4	25	i	pt	---	struck on 1754 cast George II cast counterfeit
99	New Jersey 1787 56-n	125.4 9.09	28.7 27.5	50	s	pt	1 5	56-n o/s on 1787 Conn. as parent coin
100	New Jersey 1787 62-q	96.4 8.53	29.6 29.7	50	i f	pt g	11	

Coin Illustrations

Coin #2: George I 1721 English Halfpenny
The only George I example in the study collection, this coin is distinguished by the large tab at K-6, no doubt the remnant of the ingate channel. This coin also demonstrates excellent examples of filled lettering.

Coin #19: George II 1740 English Halfpenny

This heavy example at 156.2 grains, is distinguished by having the highest zinc content of any coin in the study collection examined under x-ray fluorescence spectroscopy. Although, as a general rule, color is not a reliable indicator of composition, this yellow-brassy coin is indeed impure brass at 66.2% copper, 25.9% zinc, 4.7% lead and 3.2% tin, with specific gravity of 8.54.

Coin #26: George II 1750 English Halfpenny

A beautiful example of the state-of-the-art technology in casting counterfeit coppers, this halfpenny, with mold ports at K-1 and K-7 shows tangential (i.e. with the edge) file marks around its entire circumference. These file marks, the small but numerous pits on the reverse surface, the mold ports, a slightly reduced weight of 140.1 grains, and a specific gravity of 8.65 (significantly less than copper at 8.92) bear evidence which condemn this nearly perfect counterfeit specimen.

Coin #30: George II 1754 English Halfpenny
This otherwise typical George II halfpenny is remarkable for its mold edge-tab which extends one third the way around its circumference. This tab is the result of the mold halves not having been held together with sufficient force to prevent the molten metal from leaking into the mold interface region. Usually, when this leakage occurred, the edge of the coin was dressed with a file to resemble more a coin struck on a punched blank, but the edge of this specimen has never seen a file. Casting port at K-3 and gas vent at K-11, this coin is unusually heavy at 165.6 grains, perhaps as a consequence of the slight parting of the mold halves.

Coin #32: George III 1772 English Halfpenny
This cast halfpenny is a hybrid coin, having been made in a mold that received its impression from a struck counterfeit parent coin. With pitted and pimpled surfaces, casting port at K-11 and gas vent at K-7, filed edge and some filled letters, this unusual example shows all the characteristics expected for a cast counterfeit copper.

Coin #33: George III 1775 English Halfpenny
This example is the heaviest halfpenny in the study collection at 172.8 grains. It was cast of lead bronze, copper 82.9%, lead 12.0%, and tin 5.0%, with cast ports at K-3 and K-9. It is another hybrid example, since it is a cast copy of a struck counterfeit parent coin.

Coin #41: George III 1783 Irish Halfpenny
This lead bronze coin, copper 91.8%, lead 4.4%, tin 0.8%, and iron 3.0% is another hybrid example of a coin cast from the impression of a struck counterfeit halfpenny that was itself a 5% off-strike error. The casting port is clearly visible at about K-9 on the obverse, also the location of aggressive edge filing.

Coin #44: Nova Constellatio 1785 Crosby 2-A
With a heavily, but carefully filed edge, this coin has pitted surfaces and a large surface depression at the casting port along the rim, running from the O in Constellatio to the N in Nova.

Coin #46 Nova Ebroac 1787
Having all the characteristics of a cast counterfeit copper, including surface pitting caused by hot gases, wavy field areas, filled letters, and overall loss of detail, the alloy is 78.8% copper, 12.8% lead, and 8.4% tin. Cast and vent ports are 180º apart at K-4 and K-11 as indicated by enhanced thickness at the rim and flattening of the edge by filing at those locations.

Coin #47: Nova Eborac 1787
This example illustrates an unusually large casting port at K-1 and a vent port at K-8. A raised area on the cheek and raised pimples, especially in the obverse fields result from pits in the mold where sand has been pulled away, either on removal of the parent coin used to make the mold initially or, more likely, adhesion of a cast coin to the mold from a previous use.

Coin #50: Vermont 1788 RR-27
With a thick casting port at K-7, obliterating the V in Vermont, and gas vent at K-3, this lead bronze example (89.5% copper, 5.0% lead, 5.0% tin, and 0.5% iron) has grainy surfaces caused by a course sand mold but otherwise shows good detail. Transverse file marks (across the edge of the coin) show around essentially the entire circumference giving an impression of an irregularly milled edge.

Coin #51: Massachusetts
With good weight at 146.5 grains, this thick, but porous (specific gravity 8.01) example has mold ports at about K-4 and K-9. Its lumpy surface, poor definition, and irregular edge also give it away as a cast example although it is cast from fairly pure copper at copper 97.8%, lead 0.7%, and tin 1.5%.

Coin #54: Connecticut 1785 Miller 3.3-F.3
This coin is representative of a phenomenon noted on several other examples in the study collection, namely, a distinct difference in clarity between the sides of the coin. In this case, the obverse has fine detail while the reverse has less than 25% of the devices and lettering easily legible. For this specimen, this differential could have been caused by a combination of factors. Here, one can postulate that the 3.3 obverse was located in the drag, or lower mold half, which benefited from the positive effects of gravity to help fill the recesses of the mold thereby imparting a more distinct impression. The upper half of the mold, or cope, was the location of the F.3 reverse whose detail was obfuscated. This lack of clarity in designs was caused either by residual air, improperly vented from the mold, trapped steam, from the action of the hot metal on the moist sand, and/or by inadequately vented gases released from the cooling metal. These gases formed an obstructing interface between the upper surface of the molten metal and the reverse mold, thus impeding the flow of casting material into the interstices of the reverse devices and lettering. This situation can also be associated with a rough surface to the fields.

Coin #58: Connecticut 1785 Miller 5-F.5
This is a most unusual example which demonstrates the fragility of cast material. Whereas the surface of the coin appears smooth and hard, the center is filled with voids as described earlier. Microporosity, formed as the metal cools, results from the additive effects of shrinkage microporosity and "gas unsoundness" where entrapped gases come out of solution concentrating in center of the coin. This makes the coin intrinsically weak as demonstrated by this fractured specimen which resembles a cookie, firm on the surface while porous in the interior. This microporosity no doubt altered the "ideal" specific gravity of the specimen.

Coin #66: Connecticut 1786 Miller 5.4-G
With a casting port clearly seen at K-1, this heavy coin, 148.0 grains, is distinguished by the large bumps on the obverse, characteristic of depressions in the mold where sand had been lost. The other 5.4-G in the study collection does not show these defects and is almost 30 grains lighter. Its casting port is unambiguously seen at K-9, an indication that these two 5.4-G examples were produced in different molds.

Coin #78: Connecticut 1787 Miller 33.6-kk
With excellent detail but uniformly grainy surfaces, this example is very out of round due to aggressive filing at the casting port, K-5 and the gas vent at K-10. Course transverse file marks give this specimen an "engrailed edge" appearance.

Coin #92: New Jersey 1786 Maris 23-R
This lead bronze example (77.7% copper, 12.3% lead, and 10.0% tin) shows the consequences of profound mold failure at K-12 to K-1, pitted surfaces and filled letters. Although full weight (143.7 grains) this bronze coin is clearly a cast example.

Coin #94: New Jersey 1787 Maris 32-T
Cast from mostly copper (95.8% copper, 1.9% lead, and 2.3% tin) this example lacks overall definition. Many obverse letters are filled as is much of the striping in the shield.

Coin #98: New Jersey 1787 Maris 56-n
This interesting example is a hybrid since it is a 1787 New Jersey copper struck over a cast counterfeit 1754 English halfpenny host coin which demonstrates typically characteristic irregular edges and surface pitting! The 54 of the date on the undertype lies to the left of the shield on the New Jersey reverse, with the exergue line running vertically.

APPENDIX B

X-ray Fluorescence Spectroscopy

X-ray fluorescence spectroscopy (XRF) is a non-destructive analytical technique used to determine the concentration of chemical elements in a sample material. When the sample material is irradiated by x-ray photons, electrons are ejected form the neutral atoms in the material, converting them momentarily into ions. These ions are unstable and electrical neutrality is quickly restored by rearrangement of their orbiting electrons. In so doing, electron transitions from outer orbits to inner orbits take place and secondary x-ray photons are emitted. This process is known as x-ray fluorescence. The energies of these secondary x-ray photons are unique to each element from which they emanate. Therefore, through the use of standard samples (materials of known composition) the instrumentation used to detect the secondary x-ray photons can be calibrated, after which the element composition of unknown materials can be determined.

From a numismatic perspective, an advantage of the XRF technique, in addition to its quantitative and non-destructive nature, is that virtually no sample preparation is required, i.e. coins can be measured "as is." However, important limitations do compromise its quantitative use and these arise because only the near surface region of the coin (perhaps to a depth of 0.10 mm) is measured. Since the irradiating x-ray photons have to penetrate the coin and the secondary x-ray photons have to exit, a heavy patina or surface encrustation can reduce the accuracy of the measurement. In addition, certain types of surface enrichment processes can favor one metal in the alloy over the others, especially if the coin is buried in the ground for a long time. The coin itself is irreversible changed by these effects and although it may appear in a reasonably good state of preservation, the core of the coin will have a different composition from that of the near surface region.

The XRF measurements in this study were done at the University of Maine, Department of Physics and Astronomy.[1] The XRF spectrometer employed uses a cadmium 109 radioisotope excitation source to irradiate the sample and a lithium-drifted silicon detector to measure the secondary x-ray photons. Electrical signals from the detector are amplified and sent to a multichannel pulse height analyzer and computer, where they are recorded and stored according to their energies. A software package is used to identify the elements in the sample producing the various characteristic x-ray photon energies.

To enhance the quantitative accuracy of the measurement, several corrections to the analysis of the data are made.[2] The effects of background radiation and instrument profile are minimized using the Compton continuum subtraction method. Matrix corrections for enhanced self absorption was necessary, especially for coins in the study collection containing substantial amounts of lead. Calibration of the spectrometer, specifically for this study, was done using metal disks of known composition the same size as 18th century coppers. A set of standard disks was prepared from high purity copper, tin, zinc, lead, iron, and silver.[3] Two standard copper alloy disks were also used: bronze 932 (83% copper, 7% tin, 7% lead, and 3% zinc) and brass 260 (70% copper and 30% zinc).

For irradiation/data collection times employed, normal elemental composition to a few parts in a thousand (a few tenths of a percent) could be determined. This spectrometer can, with differing degrees of efficiency, detect the 73 elements from calcium to uranium. This span of the periodic table includes most metallic elements of numismatic interest.

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[1] We wish to thank Professor C. T. Hess and students J. J. Amsden and B. S. Bernhardt for their technical assistance and useful discussions.

[2] Eugene P. Bertin, *Introduction to X-Ray Spectrometric Analysis (*New York, 1978)

[3] We wish to thank T.W. Tripp, chief machinist, University of Maine, Department of Physics and Astronomy.